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NETWORK STANDARDS

# How Internet Standards Came to Be

Test Your Understanding

1. a) Why are Internet standards called RFCs? (Do not just spell out the name.)

Internet standards are called request for comments because the Network Working Group team didn’t feel like they had authority to call them standards.

b) What factors in the Internet’s informal development process lead to rapid standards development and low-cost products?

The IETF’s egalitarian culture was a major factor in the rapid standards development and low-cost products. They believed that anyone with a good idea should be heard. They did not ignore new ideas because their overall goal was to make something that worked and that everyone agreed on.

# INTRODUCTION

## Standard = Protocol

## Network Standards

## Recap of Chapter 1 Standards Concepts

Test Your Understanding

2. a) Give the definition of network standards that this chapter introduced.

Network standards are a set of rules that apply to how messages are exchanged between two hosts.

b) In this book, do standards and protocols mean the same thing?

Yes, it is very common to see the word protocol in the names of standards.

## Network Standard Characteristics

Test Your Understanding

3. a) What three aspects of message exchanges did we see in this section?

We learned about message order, semantics and syntax. Message order is the proper order that messages need to be sent in. Semantics is the meaning of messages. Syntax is a lot like grammar: the proper organization of messages.

b) Give an example not involving networking in which the order in which you do things can make a big difference.

When you build a house you need to do things in the right order or there will be major problems. One example is building the foundation before doing the plumbing.

c) Distinguish between syntax and semantics.

Syntax is how you organize a message, whereas semantics deals with the meaning of messages.

# EXAMPLES OF MESSAGE ORDERING

## Message Ordering in HTTP

## Message Ordering and Reliability in TCP at the Transport Layer

Test Your Understanding

4. a) Describe the simple message ordering in HTTP.

In a HTTP request-response cycle, a client will send a request to a server. When the server receives the request from the client, it will then send a response and the HTTP request-response cycle is complete.

b) In HTTP, can the server transmit if it has not received a request message from the client?

In HTTP, a server can never send a response message unless it has first received a request message from a client.

c) Describe the three-step handshake in TCP connection openings.

In the three-step handshake opening, Host A initiates communication with Host B by sending it a TCP SYN segment. When Host B receives the TCP SYN segment, it sends acknowledgement that it was received the TCP SYN segment back to Host A. Host B does this by sending Host A a TCP SYN/ACK segment. When host A receives the TCP SYN/ACK segment from Host B it sends back another acknowledgment that it received the acknowledgment segment. This acknowledgment is called a pure TCP ACK segment. And once this process is complete, a connection has been initiated between Host A and Host B.

d) What kind of message does the destination host send if it does not receive a segment during a TCP connection?

If the destination host doesn’t receive a segment during a TCP connection, it will send another HTTP request segment. Usually Host A will receive an ACK segment from Host B before Host B sends a HTTP response segment. If Host A doesn’t receive an ACK segment after a certain period of time, it will retransmit the HTTP request segment.

e) What kind of message does the destination host send if it receives a segment that has an error during a TCP connection?

If the destination host receives a segment that has an error during a TCP connection, it will dispose of the segment and send nothing.

f) Under what conditions will a source host TCP process retransmit a segment?

A source host will retransmit a segment if it doesn’t receive an ACK segment.

g) Describe the four-step handshake in TCP connection closes.

In the four-step handshake, host A will initiate the closing of a connection by sending a FIN segment. Host B will send an ACK segment back to notify Host A that it received the FIN segment. Host B may have more data segments to send so it will send the data after it send the ACK segment. Host A will then send an ACK segment back to Host B to say it got the last data segment. Host B will then send its own FIN segment to end the connection. Host A will then send a final ACK segment back and the connection is closed.

h) After a side initiates the close of a connection by sending a FIN segment, will it send any more segments? Explain.

Yes, like I explained in “g” the first FIN segment sent just initiates the Four-Step handshake closing. Host B still has to acknowledge that it got the FIN segment from Host A, and it may even have some more data segments to send to host A. It will send the ACK and Data segments to Host A and Host A will send another ACK segment. Once Host B has got that ACK segment it will send its own FIN segment and Host A acknowledges it by sending one final ACK segment to Host B and the connection is closed.

i) In Figure 2-8, suppose Host A had already sent A6 before it realized that it would need to resend A5. When it then resent A5, A6 would arrive before A5. How would Host B be able to put the information in the two segments back in order?

Host B would look at the sequence numbers A6 and A5 and realize that they were out of order. It would put them in the correct order.

# EXAMPLES OF MESSAGE SYNTAX

## Syntax: General Message Organization

Test Your Understanding

5. a) What are the three general parts of messages?

The three general parts of messages are the Data Field, Header, and Trailer.

b) What does the data field contain?

The data field contains all the content to be delivered.

c) What is the definition of a header?

The message header is everything that comes before the data field.

d) Is there always a data field in a message?

No, but there is always a header.

e) What is the definition of a trailer?

A trailer is simply everything that comes after the data field.

f) Are trailers common?

No.

g) Distinguish between headers and header fields.

Headers are everything before a data field. Header fields are smaller areas within a header that contain things such as a destination address header field, which is utilized by switches and routers in transmitting a frame or packet.

h) Distinguish between octets and bytes.

Octets and bytes are exactly the same thing: 8 bits.

## The Ethernet Frame Syntax

Test Your Understanding

6. a) How long are Ethernet EUI-48 addresses?

48 bits long.

b) What were they called traditionally?

MAC (media access control) addresses.

c) What devices read Ethernet destination EUI-48 addresses?

The destination host and switches.

d) If the receiver detects an error on the basis of the value in the Frame Check Sequence field, what does it do?

It discards the frame. It does nothing else.

e) Ethernet does error detection but not error correction. Is Ethernet a reliable protocol? Explain.

No. Reliability requires not only error detection, which Ethernet does, but also error correction, which Ethernet does not do.

## The Internet Protocol (IP) Packet Syntax

Test Your Understanding

7. a) How many octets long is an IPv4 header if there are no options? (Look at Figure 2-11.)

20 octets long.

b) List the first bit number on each IPv4 header row in Figure 2-11, not including options. Remember that the first bit in Row 1 is Bit 0.

The first bit in Row 1 is Bit 0, the first bit in Row 2 is Bit 32, the first bit in Row 3 is bit 64, the first bit in Row 4 is bit 96, and the First bit in Row 5 is bit 128.

c) What is the bit number of the first bit in the destination address field in IPv4? (Remember that the first bit in binary counting is Bit 0.)

The first bit number of the first bit in the destination address field in IPv4 is Bit 128.

d) How long are IPv4 addresses?

IPv4 addresses are 4 Octets (32 bits) long.

e) What device in an internet besides the destination host reads the destination IP address?

Routers read the destination IP addresses because they need to know where the packet is going in order to properly forward it in the right direction.

f) What is this device’s purpose in doing so?

Routers read the destination IP addresses because they need to know where the packet is going in order to properly forward it in the right direction.

g) Is IP reliable or unreliable? Explain.

It is unreliable. It does error detection, but reliability also requires error correction.

## Transmission Control Protocol (TCP) Segment Syntax

Test Your Understanding

8. a) Why was TCP designed to be complex?

TCP was designed to be complex so that it would be more reliable and do other things that the Internet Protocol does not do.

b) Why is it important for networking professionals to understand TCP?

It is important for networking professionals to understand TCP because it is more reliable and because it is also much more complex so there is less room for error.

c) What are TCP messages called?

TCP messages are called segments.

9. a) Why are sequence numbers good?

Sequence numbers are good because each segment has a sequence number which allows the receiver to confirm that there are no missing messages, ensures that all duplicate messages are deleted, and it helps to place segments in the correct order.

b) What are 1-bit fields called?

1-bit fields are called flag fields.

c) If someone says that a flag field is set, what does this mean?

It means that the field has a value of 1.

d) If the ACK bit is set, what other field must have a value?

If the ACK bit is set, the acknowledgment number field must have a value also. This will indicate the message being acknowledged.

e) What is the purpose of the acknowledgment number field?

The purpose of the acknowledgment number field is to indicate which segment that is being acknowledged.

## User Datagram Protocol (UDP) Datagram Syntax

Test Your Understanding

10. a) What are the four fields in a UDP header?

There is the Source Port Number field, the Destination Port Number field, the UDP length field, and the UDP checksum field.

b) Describe the third.

The UDP length field simply states how long the datagram (message) is.

c) Describe the fourth.

The UDP checksum field allows for error checking in the UDP datagram.

d) Is UDP reliable? Explain.

UDP is also not reliable because like Ethernet and IP, if an error is found, the entire message will be discarded, and there will be no automatic retransmission.

## Port Numbers

Test Your Understanding

11. a) What type of port numbers do servers use for common server programs?

Servers use “well-known port numbers.” These well-known port numbers have a port number range reserved from port 0 to port 1023. Certain programs are normally on a certain port, like HTTP application programs which are usually on port 80.

b) What type of port numbers do clients use when they communicate with server programs?

Clients use ephemeral port numbers. Ephemeral port numbers are randomly assigned to a client each time a client initiates or accepts a connection.

c) What is the range of port numbers for each type of port?

Well-known port numbers range from port 0 to port 1023, and ephemeral port numbers range from port 1024 to port 4999.

d) How are ephemeral port numbers generated?

They are randomly generated each time a client initiates or accepts a connection.

e) Why are they called *ephemeral*?

They are called ephemeral because they are discarded whenever a connection is ended.

12. a) What is the syntax of a socket?

The syntax of a socket Is “IP address:Socket#”

b) In Figure 2-14, when the client transmits to the mail server, what is the source port number?

2707

c) What is the destination port number?

80

d) What is the source socket?

60.171.18.22:2707

e) What is the destination socket?

1.33.17.13:80

f) When the SMTP server transmits to the client host, what is the source port number?

4400

g) What is the destination port number?

25

h) What is the source socket?

60.171.18.22:4400

i) What is the destination socket?

123.30.17.120:25

## HTTP Request and Response Message Syntax

Test Your Understanding

13. a) Is the application layer standard always HTTP?

No, there are many standards that can be used at the application layer (L5).

b) Which layer has the most standards?

The application layer (L5) has the most standards.

c) At which layer would you find standards for voice over IP? (The answer is not explicitly in this section.)

Since voice over IP is an application, you would find standards for it on the Application Layer (L5).

d) Are all application layer standards simple like HTTP?

No.

e) In HTTP response headers, what is the syntax of most lines (which are header fields)?

In HTTP response headers the first line consists of a statement saying that it will be speaking a certain version of HTTP, and then it will give a code that will describe the type of response. It then contains the date and time, the name of the server, and then two lines describing the webserver software and what type of data is in the field below the header. After that there is a CRLF line and the header is finished.

f) In HTTP request and response message, how is the end of a field indicated?

In HTTP request and response messages the end of a field is indicated by a CRLF or carriage return line feed which indicates the start of a new line.

g) Do HTTP request messages have headers, data fields, and trailers?

HTTP request messages only have headers, and there is no data field or trailer.

h) Do HTTP response messages that deliver files have headers, data fields, and trailers?

HTTP response messages that deliver files have headers and data field, but they do not have trailers.

# CONVERTING APPLICATION MESSAGES INTO BITS

## Encoding

Test Your Understanding

14. a) What is encoding?

Encoding is the conversion of messages into bits.

b) At what layer is encoding done?

Encoding is done at the application layer (L5).

## Encoding Text as ASCII

Test Your Understanding

15. a) Explain how many bytes it will take to transmit “Hello World!” without the quotation marks. (Check Figure: 12.)

It will take 12 bytes to transmit “Hello World!”. Each letter, space and symbol will be translated into ASCII code. Each letter, space, and symbol will be 7 bits long and the 8th bit is always unused and 1 byte = 8 bits. There are 10 letters, 1 space, and 1 symbol in “Hello World” so therefore it will take 12 bytes to transmit “Hello World!”.

b) If you go to a search engine, you can easily find converters to represent characters in ASCII. What are the 7-bit ASCII codes for “Hello world” without the quotation marks? (Check: H is 1001000.)

H=1001000 e= 1100101 l=1101100 l=1101100 o=0110000 (space)= 100000 W=1010111 o=110000 r=1110010 l=1101100 d=1100100 != 100001

## Converting Integers into Binary Numbers (1s and 0s)

Test Your Understanding

16. Answer the following without a calculator.

a) What is an integer?

An integer is a whole number.

b) Is 4,307 an integer?

Yes.

c) Is 45.7 an integer?

No, but it is a decimal number.

d) Convert the binary number 100 to decimal. (Check Figure: 4.)

4

e) Convert the binary number 1111 to decimal

15

f) Convert the binary number 10110 to decimal.

22

g) Convert the binary number 100100 to decimal.

36

h) Convert the decimal number 8 to binary. (Check Figure: 1000.)

1000

i) Convert 6 to binary (Check Figure: 110.)

0110

j) Convert 15 to binary.

1111

k) Convert 67 to binary.

1000011 (1-four zeroes-11)

## Encoding Alternatives

Test Your Understanding

17. a) What does the equation *a* = 2*b* mean?

A represents the number of alternatives, and b represents the number of bits.

b) How many alternatives can you represent with a 4-bit field? (Check Figure: 16.)

16

c) For each bit you add to an alternatives field, how many additional alternatives can you represent?

For each bit you add, the number-of-alternatives field doubles.

d) How many alternatives can you represent with a 10-bit field? (With 8 bits, you can represent 256 alternatives.)

A 10-bit field can represent 1024 alternatives.

e) If you need to represent 128 alternatives in a field, how many bits long must the field be? (Check Figure: 7.)

7 bits.

f) If you need to represent 18 alternatives in a field, how many bits long must the field be?

5 bits.

g) Come up with three examples of things that can be encoded with 3 bits.

This gives 8 alternatives.

North, South, East, West, North East, North West, South East, South West.

The five senses.

## Encoding Voice

Test Your Understanding

18. a) Why is the electrical signal generated by a microphone called an analog signal?

The electrical signal generated by a microphone is called an analog signal because it is analogous to the human voice; the signal rises and falls based on the loudness of your voice.

b) What two things does a codec do?

A codec encodes analog signals into digital signals, and decodes digital signals into analog signals.

c) Is there a single codec standard?

No, there are many.

# VERTICAL COMMUNICATION ON HOSTS

Test Your Understanding

19. a) What is encapsulation?

Encapsulation is when a message is placed in the data field of a separate message.

b) Why is encapsulation necessary for there to be communication between processes operating at the same layer but on different hosts, routers, or switches?

Each layer has a different process when a message is sent. A message can’t be sent directly from the application layer on the source host, so it has to send it down the layers, and when it reaches the destination host, it goes back up the layers to the destination hosts application layer. Each layer specializes in something in the transmission of a message.

c) After the internet layer process in Figure 2-21 receives the TCP segment from the transport layer process, what two things does it do?

After the L3 process receives the TCP segment from the L4 process, it encapsulates the TCP segment in the data field of an IP packet, and then it sends the IP packet to L2.

d) After the data link layer process in Figure 2-21 receives the IP packet from the internet layer process, what two things does it do?

After the L2 process receives the IP packet from the L3 process, it encapsulates the IP packet in the data field of an Ethernet frame and then sends it to L1.

e) After the physical layer process receives a frame from the data link layer process, what does the physical layer process do?

After the L1 process receives a frame from the L2 process, it converts the bits of the frame into signals and transmits the signals to a switch, router, or host.

f) If encapsulation occurs on the source host, what analogous process do you think will occur on the destination host? (The answer is not in the text.)

“Decapsulation” will occur at the destination host. It will send the message back up through the layers until the actual message is received at the application layer.

# CONCLUSION

## Synopsis

## End-of-Chapter Question

Thought Questions

2-1. How do you think TCP would handle the problem if an acknowledgment were lost, so that the sender retransmitted the unacknowledged TCP segment, therefore causing the receiving transport process to receive the same segment twice?

TCP utilizes segment numbers so that problems like this are easily fixable. Every segment has a sequence number which allows the receiver to confirm that there are no missing messages and ensures that all duplicate messages are deleted, and it helps to place segments in the correct order.

2-2. a) In Figure 2-14, what will be the value in the destination port number field if a packet arrives for the e-mail application?

The value in the destination port number field will be 25.

b) When the HTTP program on a webserver sends an HTTP response message to a client PC, in what field of what message will it place the value 80?

It will place the value 80 in the destination port number field.

2-3. Do the following without using a calculator or computer, but check your answers with a calculator or computer.

a) Convert 110100 to decimal. (Check Figure: 52.)

52

b). Convert 001100 to decimal.

12

c) Convert 7 to binary. (Check Figure: 111.)

0110

d) Convert 47 to binary.

101111

e) Convert 3,270 to binary.

110011000110

2-4. Do the following without using a calculator or computer, but check your answers with a calculator or computer. You need to represent 1,026 different city names. How many bits will this take if you give each city a different binary number? Explain your answer.

It would take 11 bits to represent 1,026 different city names. 10 bits wouldn’t be enough because you would only have 1,024 alternatives. With 11 bits you can have 2,048 alternatives but you will only use 1,026.

Brainteaser Questions

2-5. How can you make a connectionless protocol reliable? (You may not be able to answer this question, but try.)

Reliability is more difficult if there are not sequence numbers. After sending a message, the receiver would have to stop and wait for an acknowledgement. This would work, but it would slow things down.

2-6. Spacecraft exploring the outer planets need reliable data transmission. However, the acknowledgments would take hours to arrive. This makes an ACK-based reliability approach unattractive. Can you think of another way to provide more reliable data transmission to spacecraft without using acknowledgments? (You may not be able to answer this question, but try.)

You would use forward error correction. You would send the message with redundant bits arranged in a way that allows the receiver to correct errors, instead of asking for a retransmission. This method is used in 802.11 Wi-Fi in addition to acknowledgements.

Perspective Questions

2-7. What was the most surprising thing you learned in this chapter?

Student answers will vary.

2-8. What was the most difficult material for you in this chapter?

Student answers will vary.